Written Testimony by Donna Shirley
To The House Committee on Science Hearing Entitled
Perspectives on the President's Vision for Space Exploration
Wednesday, March 10, 2004, 10:00 a.m.
Room 2318 of the Rayburn House Office Building.

Abstract

In my opinion human space exploration is justified by the natural predilection of humans to explore. Humans could conduct science at the moon or Mars but are generally not as effective as robots for this purpose. Humans and robots will be partners in exploration. The International Space Station can be useful as a facility for evaluating human physiology and psychology to prepare for exploration. But if the goal of exploration is to send humans to Mars the moon is of little value in such preparation and, in fact, is a diversion of time and money from the goal. The costs of the program are difficult to evaluate but there appear to be several strategic flaws, including a possibly premature phase-out of the shuttle and premature focus on a specific approach. There is no real information on which to judge the impact of exploration on other NASA missions. I will make several recommendations for revisiting and improving the vision, specifically to include a wide range of "stakeholders" including private space enterprise and non-traditional technologies.

Testimony

I am Donna Shirley, Director of the Science Fiction Museum and Hall of Fame in Seattle, Washington. I was recently Assistant Dean of Engineering at the University of Oklahoma and before that I retired in 1998 as Manager of the Mars Exploration Program at the Jet Propulsion Laboratory. During my 32-year career at JPL I worked on a number of human exploration missions including participating in the initial design of the space station in the early 1980's and in studies of human missions to the moon and Mars in the 1980's and 1990's. I led two NASA-wide studies in the 1990's, one of which developed a standard process for systems engineering for the Agency[1] and another of which analyzed and recommended improvements to NASA's program and project management processes.

My remarks are my own opinions and do not reflect the views of the Science Fiction Museum. However I would like to speak from the perspective of a person who was inspired by science fiction to pursue an engineering career, and who continues to be inspired by the inventiveness of science fiction writers. I will take a cue from Neil Armstrong, who recently used a science fiction theme to talk about the relative roles of humans and robots in space exploration. The popularity of science fiction teaches us that people are fascinated with the idea of exploration. Studies of history, anthropology and primate behavior teach us that humans have a built-in imperative to seek new terrain, just as the crew of the Starship enterprise "explores strange new worlds". Mr. Armstrong pointed out that an early science fiction play, *Rossum's Universal Robots*, stressed the utility of having robotic laborers to do dangerous, dull or dirty tasks. But science fiction from Buck Rogers to the modern Mars novels like *Red Mars* shows that people also want to explore the cosmos.

[1] SP 6105, NASA Systems Engineering Handbook, June 1995

In this context I will address the several questions I was asked by the Committee in the context of the President's Vision as summarized in a White House press release.[2]

What are compelling justifications for sending humans into space? Does the President's initiative provide adequate justification for sending humans to the moon and Mars?

The quick answer is to the second question is "yes". The justification is that the need to explore is "wired into our DNA". Neuroscience has discovered changes in the brains of adolescents related to their propensity for risky adventures.[3] And many people routinely engage in risky behaviors for the thrill of it. Many adults have a desire to go into space and two, Dennis Tito and Mark Shuttleworth, have paid millions to the Russians for the opportunity to visit the ISS. Studies show that thousands of people may be willing to pay six figures for even a sub-orbital ride.[4]

However, while the justification for human exploration is clear, the justification for the moon as a destination before Mars is not. If the goal is humans on Mars the moon is an expensive and time-consuming delay. So the general vision is good, but the feasibility of the proposed implementation is not clear.

The "moon first" part of the vision is overly specific. There needs to be a process for deciding what should be targets and how to reach them. One of NASA's mistakes is to keep trying to repeat Apollo with Wernher von Braun's 70-year old vision for human space exploration.

To what extent would scientific research concerning Mars be aided by a human presence on, or in orbit around that planet?

Humans would do science if they went, but should not go just to do science. For example, studies have shown that semi-autonomous rovers on Mars given direction by humans on Earth are far more effective in exploration (in distance and especially dollar for dollar) than rovers "teleoperated" by humans from Mars orbit.[5]

The argument that only humans can do science "in situ" is flawed. The lunar "orange dirt" noticed by Harrison Schmitt[6], first (and last) scientist on the moon, is used as evidence that robots could never have noticed such a scientifically important find. But the truth is that robots such as Spirit and Opportunity, who are currently on Mars, have a far wider range of senses

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[2] http://www.spaceref.com/news/viewpr.html?pid=13412, from PRESS RELEASE, Date Released: Wednesday, January 14, 2004, Source: White House, President Bush's Vision for U.S. Space Exploration

[3] "Adolescent Brain Development and Legal Culpability" American Bar Association, Criminal Justice Section, Spring 2003.

[4] Crouch, Geoffrey, "Researching the Space Tourism Market", Presented at the annual Conference of the Travel and Tourism Research Association, June 2001

[5] AIAA-90-3785, "Site Characterization Rover Missions", D.S. Pivirotto, Sept 25-28, 1990, Huntsville, AL

[6] http://www.spacetoday.org/History/SpaceFactoids/SpaceFactoids3.html, "Apollo 17 astronaut Harrison Schmitt, the first geologist in space, found the most colorful stuff on the Moon -- orange glass -- near Shorty Crater. That suggested the possibility of ice within the Moon."

than a human.[7] Robots merely extend human senses both in distance and wavelength. The Mars rovers' instruments can "see" in wavelengths far beyond human sight. Their instruments return data so that scientists on earth can perceive the Martian surface in ways that humans on Mars (unless they were carrying such instruments) could not.

Are the International Space Station and the moon the most appropriate stepping-stones for human space exploration if the ultimate objective is a human landing on Mars? What would be the advantages and disadvantages of a program that was targeted instead on sending a human directly to Mars? To what extent is research on the International Space Station likely to help remove the hurdles to long-duration space flight?

The appropriateness of the ISS and the Moon depend on the program objectives, which should be policy decisions based partially on technical feasibility and cost. An informed and open national and international discussion is needed to support these policy decisions.

The lack of widely supported objectives for NASA has led, for example, to its budget being increasingly eroded by Congressional earmarks largely, in my opinion, because there is not a perception of NASA's intrinsic value or purpose

I worked on a precursor to the current ISS in the early 1980's and it was clearly deliberately designed as a jobs program rather than as the most cost-effective solution to human exploration. (And realistically this will always be true of a large federally funded undertaking). Because of the use of Russian launchers to supply the station it is not in a good orbit for staging of assets for on-orbit assembly of missions to the moon or planets. However, the ISS could be useful for studying physiology to prepare for human missions to Mars, and it is important to keep our commitments to our international partners who have invested a large amount of resources and who are waiting to have their hardware installed on the station.

The ISS will help human space exploration if its mission is focused on research on the impacts of living in space on the human physiology and psychology. The President's vision takes this step, however several things are needed to make this work that are not currently in the station design, for example:

- A centrifuge to explore impacts of partial gravity on recovery from bone loss and muscle weakness. Will astronauts be able to function in the 3/8 gravity of Mars after a several month zero-g passage?
- Radiation research. The ISS is protected by Earth's magnetic field but the radiation environment on Mars is very severe because Mars lacks a magnetic field and a thick atmosphere.

Phase-out of the shuttle in 2010 will make it very difficult to operate the ISS even if construction can be completed by then. Even if there is not another failure before the end of the ISS there is predicted to be a four-year gap between the end of the shuttle and the

[7] "Opportunity Rover Finds Strong Evidence Meridiani Planum Was Wet", March 2, 2004 Press Release, http://marsrovers.jpl.nasa.gov/newsroom/pressreleases/20040302a.html

availability of the crew exploration vehicle. Human transport can continue to rely on the reliable Russian launchers and landers. However, while European, Russian and Japanese vehicles can supply the station, none of these is designed to bring cargo *down*, so any large science instruments must either be thrown away or not used if the shuttle is not available. The current plan scraps alternate US cargo carriers.

The Moon is a complete diversion from human missions to Mars. The suggestion that there are materials on the Moon that can be used to build systems to go to Mars is totally unfounded. The Moon has no useful resources for Mars exploration (Water at the poles is problematic, and even if it exists is probably infeasible to "mine" in large quantities.) Everything taken to the Moon must be lifted out of the gravity well of the Earth. Even if resources did exist on the Moon, which would be useful, the mass of equipment to mine them in quantities required for a Mars mission would far exceed the benefit of launching to Mars from the lower lunar gravity.

The high cost of building a lunar infrastructure will divert resources from Mars with no added value for Mars missions because the cost of lifting equipment to Moon will far exceed the benefits.

There is little technology commonality between the Moon and Mars because of the different environments. For example, space suits designed for vacuum will not work in the Martian atmosphere. Landing systems on Mars can make use of the atmosphere unlike those for the Moon. Thermal environments between Moon and Mars are radically different. And so on.

The Moon is a scientifically interesting place in its own right but missions of exploration including the installation of large astronomical telescopes on the far side can be done robotically. Even modern science fiction does not revolve around an economically viable Moon, and previous assumptions of plentiful water on the Moon have been shown not to be true. For example, Heinlein's *The Moon is a Harsh Mistress* [8] was based on an economy, which grew grain using vast stores of underground water.

Helium 3 mined on the Moon and "burned" in a fusion reactor is often touted as a boon for energy production.[9] However, both Helium 3 mining and fusion technology are completely unproven, and a positive benefit/cost ratio has not been demonstrated. Furthermore, even if fusion and mining technologies were feasible, they will not be relevant to space exploration in any meaningful time frame.

The President's initiative also mentions Libration Points, Asteroids, etc as destinations, but there appear to be no benefits of these objectives to Mars exploration (or to human exploration) and more justification is needed if they are selected.

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[8] Berkley Publishing, 1966

[9] http://www.space.com/scienceastronomy/helium3_000630.html, "Moon's Helium-3 Could Power Earth" By Julie Wakefield, Special to SPACE.com, 30 June 2000

Mars is probably the only human-accessible place in the Solar System for sustained human presence

- The Opportunity rover and the Odyssey orbiter have found past and present water. Future missions will determine locations and quantity of extant water, which may be inadequate to support humans.
- The moons of the Outer planets have ample water supplies but are too distant and dangerous for humans to explore for generations.
- Modern science fiction provides reasons and scenarios for a human presence on Mars, for example:
  - *Red Mars*, *Green Mars*, and *Blue Mars* (Kim Stanley Robinson)[10]
  - *Mars* and *Return to Mars* (Ben Bova)[11]
  - *Moving Mars* (Greg Bear)[12]
  - *Voyage* (Stephen Baxter)[13]

Does the proposed initiative achieve the proper balance among NASA's activities? Particularly, is the balance between exploration, space science and earth science, and between human and robotic missions appropriate?

This question is very difficult to answer because a much more detailed architecture is needed to see what balance is actually being achieved.

The cost of the program needs to be analyzed. The only mission that has been identified for sacrifice is the Hubble servicing. And in fact I believe a robotic servicing mission could be designed and implemented for the price of a single shuttle launch. Technology to grapple with a spinning satellite has been available since the late 1980's[14] and it should be relatively simple to keep Hubble running using a robotic Orbital Maneuvering Vehicle[15]. The OMV would then be useful for on-orbit construction and servicing and is usually included in human exploration mission designs. This approach would not risk humans to service Hubble but also would probably not save any money.

History shows that the real costs of a large program cannot be reliably estimated until 5 to 10 percent of the funds have been expended. However many, many studies of human exploration have been done over the years and if the best were "mined" at least rough estimates should be feasible now[16,17,18,19].

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[10] Bantam Books 1993, 1994 and 1996
[11] Bantam Books 1992 and 1999
[12] Tor Science Fiction 1994
[13] Harper Collins 1996
[14] IAF-87-24, "NASA's Telerobotics R&D Program: Status and Future Directions", D.S. Pivirotto and G. Varsi, Brighton, United Kingdom, 10-17 October 1987.
[15] http://www.abo.fi/~mlindroo/Station/Slides/sld011.htm
[16] *NASA Leadership and America's Future in Space*, A Report to the Administrator by Dr. Sally K. Ride, August 1987
[17] *Report of the 90-Day Study on Human Exploration of the Moon and Mars*, NASA, Washington DC, 1989
[18] National Commission on Space *Pioneering the Space Frontier*, the Report of the National Commission on Space, Bantam Books, 1986.
[19] *America at the Threshold: America's SpaceExploration Initiative*, Report of the Synthesis Group, 1991

What criteria should be used to determine whether robots or humans should conduct particular science and exploration missions on the Moon and Mars? What missions should only humans conduct on the Moon and Mars?

Humans **and** robots should be part of an integrated program. It is not humans **vs.** robots but how a partnership of "metal and mortal" can be most effectively used. Criteria should be extracted from program objectives (why, where, when?) which should be the subject of national and international discussions and debates. A number of studies and publications have addressed this.[20,21]

Humans will never "only" conduct missions by themselves. Robots will always be necessary as precursors, preparers and partners for humans. As mentioned earlier, robots are extensions of human perception. They currently act as scouts to determine safe and interesting places for people to operate. They will be used to prepare those places for humans by making fuel from in situ resources and building infrastructure. They will support humans by fetching and carrying, exploring beyond the reach of human habitats and transports, and carrying cargo to and from Earth.

If the costs of carrying out the President's proposal increase above what NASA currently projects them to be, would you recommend that NASA adjust the schedule for achieving specific milestones of the President's vision or use the budget authority from other NASA programs not related to the President's vision (e.g., Earth science or aeronautics research and development)?

NASA has not specifically projected the costs of the President's proposal and to some extent this is appropriate since a detailed analysis and design has not been done. However, costs can be inferred.

- A program cost of about $170B through 2020 can be inferred from the NASA 2005 budget projections.[22] This is less than half of the DoD budget for 2005 alone.[23]
- A lower bound estimate of about $50B for a single human Mars mission was projected by Robert Zubrin in *A Case for Mars*.[24]
- Costs of up to $450B (in 1990 dollars)[25] have been projected by NASA studies

[20] Pivirotto, D.S., "A Goal and Strategy for Human Exploration of the Moon and Mars", published in the Journal of Space Policy, 0265-9646/90/030195-14, 1990 Butterworth-Heinemann Ltd.
[21] Pivirotto, D.S., "A Goal and Strategy for Human Settlement of the Moon and Mars: Part Two", Case for Mars IV, Boulder, CO, 4-8 June 1990.
[22] http://www.nasa.gov/about/budget/ Administrator O'Keefe's Budget Presentation, Chart 14, 2.24.04
[23] http://www.defenselink.mil/releases/2004/nr20040123-0263.html, Defense Department Announces 2005 Budget Request, No. 046-04, January 23, 2004
[24] Touchstone Books 1996
[25] Costs estimated during the NASA "90 Day Study" have been widely quoted but never officially published: NASA, *Report of the 90-Day Study on Human Exploration of the Moon and Mars*, NASA, Washington, D.C., 1989.

- Certainly the $11 or $12B called out for the Crew Exploration Vehicle will only produce a human carrier with no place to go except the ISS. There is no mention of the much larger costs of launch, on-orbit assembly, infrastructure at the Moon and/or Mars, etc.
- Robotic Mars missions are costing around $400M apiece which is the equivalent of about one STS launch.

The proposed phase-out of the STS in 2010 is extremely risky for the ISS and for exploration. Such a risk led to the dependence on the development of the shuttle to re-boost Skylab, the first space station. When the shuttle development did not meet the projected schedule Skylab re-entered the atmosphere and was lost. It is also not clear that any new systems will be substantially safer than an upgraded shuttle.

The question of which missions should be sacrificed to the human exploration initiative is one of public policy. So far the budget appears to continue to support science missions, but the real costs and sacrifices have not been identified past 2005.

The schedule must reflect budget realities and the entire NASA budget would have to be greatly increased to carry out the program. Even the sacrifice of science or technology would probably not provide the resources needed with the current plan.

Observations and Recommendations: Fundamentally the whole approach needs to be re-thought. NASA continues, as it has for its entire existence, to pursue the approach that Wernher von Braun proposed in Collier's Magazine in 1952 – rocket launches, a space station, lunar and Mars bases.[26] This approach can be visualized by watching the movie *2001: A Space Odyssey*. But times have changed and we need to look at new approaches:

- New Ideas and Analysis Tools: Since Apollo NASA has had few new ideas about how to explore space. A recent presentation by a young NASA engineer showed exactly the same visualization and study tools[27] as my colleagues and I used in the late 1980's and was a rehash of the same concepts we were studying then. [28]
- New technologies: For example, the space elevator, the subject of Arthur C. Clarke's 1956 *Fountains of Paradise*[29] appears to be close to being enabled by structures built with carbon nanotubes and commercial ventures are being undertaken to build one. This is a system that puts a space station in a geosynchronous orbit 23,000 miles above the earth and lowers a cable to a point

[26] http://www.astronautix.com/lvs/vonbraun.htm, '1952 Feb 11 - *Collier's* Man Will Conquer Space Soon *Collier's* magazine published papers from First Symposium on Space Flight, under the title "Man Will Conquer Space Soon.". This was an important step in the popularization of the idea of manned space flight.'

[27] Geffre, J., "A Summary of Recent NASA Exploration Architecture Studies", National Academies Workshop, "Stepping Stones to the Future of Space", 23 February 2004, chart 10 compare with page 45 of next reference.

[28] JPL Document, "A Robotic Exploration Program: In Response to the NASA 90-Day Study on Human Exploration of the Moon and Mars", 1 December 1989

[29] Downloadable Edition http://www.amazon.com/exec/obidos/tg/detail/-/B000063JZ3/ref=lpr_g_4/103-0149313-3021408?v=glance&s=ebooks

on the equator. Once this (admittedly expensive) infrastructure was in place it could be used to launch payloads beyond earth orbit. A preliminary design and cost estimates for a commercial space elevator system[30] were funded by the NASA Institute for Advanced Concepts which routinely provides seed funding for innovative space exploration concepts. However, none of NASA's human exploration studies are looking at anything creative like the use of a space elevator[31]. This is not to say that it is the answer, just that new approaches enabled by new technology should be considered.

- New Economics: Wealthy people are entering the game. Dennis Tito and Mark Shuttleworth are the vanguard of space tourism and many companies are vying to put people in orbit. A new bill to provide regulatory standards has just passed the House of Representatives. [32] Some examples of new launch companies, with their backers, are[33]:
    - Scaled Composites – Paul Allen
    - Armadillo Aerospace – John Carmack
    - Space Exploration Technologies – Elon Musk
    - Blue Origin – Jeff Bezos
- New ways of doing business: NASA is proposing a series of "challenge" prizes to stimulate innovative approaches to space exploration.[34] However, this is not a substitute for a well-planned program with specific, affordable goals and it still leaves NASA firmly in control. What is the process for infusing the successful approaches into the human exploration program? Or, what is the process for substituting successful approaches for the government-provided elements?
- New international players: China's *Shenzhou* program has orbited its first taikonaut. The US needs either to compete or cooperate with the Chinese but the current vision is silent on this.
- New Culture: NASA has become, over the years, an entrenched bureaucracy shaped by political considerations such as keeping jobs in particular states and Congressional districts. The Columbia Accident Investigation Board stressed the need for culture change[35] and NASA is bringing in new personnel, mostly

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[30] The Space Elevator: A Revolutionary Earth-to-Space Transportation System, Publisher**:** Bradley C. Edwards & Eric A. Westling; ISBN: 0972604502; (January 14, 2003)

[31] Mankins, J.C., "Advanced Systems, Technologies, Research and Analysis to Enable Future Space Flight Capabilities and Realize the U.S. Vision for Space Exploration", presented to Stepping Stones to Space National Academies Workshop, 23 February 2004.

[32] "House Approves H.R. 3752, The Commercial Space Launch Amendments Act of 2004", http://www.spaceref.com/news/viewpr.html?pid=13774

[33] Horvath, Joan, "Blastoffs on a Budget", to appear in Scientific American, April 2004, Volume 290, Number 4.

34 "NASA exploration office charts new procurement territory", March 3, 2004, http://www.govexec.com/dailyfed/0304/

[35] http://anon.nasa-global.speedera.net/anon.nasa-global/CAIB/CAIB_lowres_chapter9.pdf, Report of Columbia Accident Investigation Board, Volume I, Section 9.3. Long Term: Future Directions for the US in Space - "The Board Does believe that NASA and the nation should give more attention to developing a new "concept of operations" for future activities...." Page 210

military[36], to help with that situation. However, the plans for the initiative which are based on the military model (such as "spiral" and "block development" that are used successfully for aircraft production)[37] may not be applicable to the relatively small number of vehicles involved in human space exploration. NASA is attempting to revitalize its workforce [38] and improve its management practices.[39] However, the fundamental nature of the civil service-staffed centers will make it very difficult to create real change. Approaches such as converting the centers from civil services to contract organizations such as the Jet Propulsion Laboratory should be explored. Attempts to "privatize" fundamentally non-profit endeavors, such as the United Space Alliance's contract to maintain the shuttle, are merely disguising ordinary government contracting as private enterprise.

A very recent report of a workshop of the National Academy of Science gives guidance for formulating human space exploration objectives. One point that it makes is: "Much of the success of the success of NASA's science programs was attributed to having clear long-range goals and roadmaps that are framed by scientists and periodically reassessed by the science community in the light of new knowledge and capability".[40] An example of this is the current Mars Exploration program which sends robotic missions every 26 months to "follow the water" to investigate whether life might have ever existed on Mars[41]. The current successful Mars rovers are a result of this approach.

Unfortunately the President's vision skips over the need for a process to provide goals for the program. Like most other human programs it merely states goals and plunges directly into an implementation strategy. This has been shown over and over to be a flawed strategy as I point out in a paper presented in 2000 at a workshop planning Human Exploration. [42] In this paper I made recommendations that I still regard as important for achieving what the President's strategy lacks:

- "Customer" Input – for example through "deliberative polling"[43] and surveys[44]. This would be from and by people outside NASA and the government, and outside the standard NASA advisors such as the National

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[36] http://www.spaceref.com/news/viewsr.html?pid=12052
[37] http://www.spaceref.com/news/viewsr.html?pid=12052, Briefing Charts: NASA Associate Administrator Craig Steidle, Office of Exploration Systems Chart 14,
[38] http://nasapeople.nasa.gov/hclwp/index.htm
[39] http://www.spaceref.com/news/viewpr.html?pid=13739
[40] Issues and Opportunities Regarding the U.S. Space Program: A Summary Report of a Workshop on National Space Policy (2004) Space Studies Board (SSB), Aeronautics and Space Engineering Board (ASEB)
[41] AIAA 96-0333, "Mars Exploration Program Strategy: 1995-2020", D.L. Shirley and D.J.McCleese, Jan 15-18, 1996, Reno, NV
[42] Shirley, D.L., "The Myths of Mars: Why We're Not There Yet and How to Get There", Workshop on Concepts and Approaches for Mars Exploration, Lunar and Planetary Institute, Houston, TX, 18-20 July 2000.
[43] NASA Human Exploration and Development of Space Enterprise: A Concept Paper On "An Over-Arching Enabling Process for the Development of an Engagement Plan", D. Powe, L.A. Ritchie, and D.L. Jackson
[44] http://www.planetary.org/html/society/press/survey_results.htm, 50,000 People Jam Planetary Society Website to Take Space Survey about NASA Priorities

Academies, and even outside the aerospace engineering and science community. The people are paying for it, shouldn't they have a real say?
- A flexible, step-by-step approach with planning and redesign in response to things learned, either from science, engineering or economic/policy changes, in other words a "decision tree" approach with options to be exercised based on learning.[45]
- Honesty, openness, flexibility, patience and hard-nosed, non-political management[46,47].

I recommend that the Committee urge the Administration to create a process for developing a truly fresh approach to the exploration of space. There should be a workshop or series of workshops to infuse non-NASA, non-government ideas into the selection of a vision. Then there should be a study effort over the next year or so to generate new concepts, bring in new players, fully engage the public and develop a set of goals.

The process should include for example

- Creative individuals, for instance Science fiction writers and movie producers
- Contestants in University robotics competitions
- Scientists and engineers
- Space Entrepreneurs
- Interested public
- Formal and informal educators
- Public Relations people
- Potential international participants.

Finally, a process should be developed for driving the human space exploration with the results of this study. This will not be an easy task, as government institutions are not accustomed to such an open process.

The Objective: Define a new vision and new architectures and approaches for human space exploration and a program to carry them out. The Science Fiction Museum and Hall of Fame would be delighted to participate in such a process.

Thank you.

[45] For instance see "Pivirotto, D.S. "Assessing Risks and /Mars Benefits of Lunar oration", 1991

[46] Shirley, D.L., "Written Testimony or the Root Causes of the Mars Surveyor 98 Mission Failures, 30 April 2000.

[47] ASEE 2002-406, Shirley, D.L., "Managing Creativity: A Creative Engineering Education Approach, 2002 American Society for Engineering Education Annual Conference, 2002.

Vitae
March 2004
Donna L. Shirley

PRECIS

Donna Shirley is Director of the Science Fiction Museum and Hall of Fame in Seattle, Washington. She recently retired as Assistant Dean of Engineering and Instructor of Aerospace Mechanical Engineering at the University of Oklahoma (OU) where she led strategic planning and the development of innovative engineering education programs, and was also President of Managing Creativity, a speaking, consulting and training firm. She is a well known educator, speaker, consultant and trainer on the management of creative teams. Ms. Shirley has an MS in Aerospace Engineering and three honorary doctorates, plus over forty years experience in engineering of aerospace and civil systems, including thirty years in management. She had a 32 year career at NASA's Jet Propulsion Laboratory, culminating in the position of Manager of the Mars Exploration Program.

SUMMARY OF EMPLOYMENT HISTORY

Science Fiction Museum and Hall of Fame

- January 2003-Present: Director of a unique, interactive science fiction museum in Seattle, WA.

Managing Creativity

- 1997-Present: President of Managing Creativity. Providing speaking, consulting and training on the management of creative teams.
- 1998-2001: Co-creator and Official Spokesperson, White House Mars Millennium Project, a nationwide educational project for K-12 students[48].

University of Oklahoma

- September 2002-2003:Instructor of Aerospace Mechanical Engineering (AME).
- September 1999-September 2002: Assistant Dean of Engineering for Advanced Program Development. Led the creation of a strategic plan for the College of Engineering. Led the modernization of the Aerospace Engineering curriculum into an "intelligent aerospace systems" program. Acted for one year as the Interim Director of Engineering Education for the College, focussing on project-based, multidisciplinary engineering.
- 2000-2004: Served on National Research Council Task Forces on the Usefulness and Availability of NASA's Earth and Space Science Data, and the National Aerospace Initiative.
- 1998-2001: Co-creator and Official Spokesperson, White House Mars Millennium Project, a nationwide educational project for K-12 students.

Jet Propulsion Laboratory (JPL)
California Institute of Technology Pasadena, California (1966-1998)

- 1994-98: Manager of the $150 million/year Mars Exploration Program, which included the highly successful Pathfinder and Mars Global Surveyor missions plus two additional missions to Mars every 26 months until at least 2005.
- 1992-94: Mars Pathfinder Microrover Flight Experiment Manager. Leader of the team which developed Sojourner Truth, the $25 million Microrover landed by Mars Pathfinder on July 4, 1997.
- 1991-92: Cassini Project Engineer. Chief Engineer of a $1.6B project to explore Saturn.
- 1989-93: (Additional Duty) Leader of two NASA-wide, award-winning teams which developed systems engineering and project management processes for the National Aeronautics and Space Administration.
- 1990-91: Manager of Exploration Initiative Studies.
- Various management and technical positions from 1966.

EDUCATION

- Some work in a Ph.D. Program in Human and Organizational Systems - The Fielding Institute, Santa Barbara, CA, 1997-98.
- MS Aerospace Engineering-University of Southern California, 1968.
- BS Aerospace Mechanical Engineering - University of Oklahoma, 1965.

- BA Professional Writing - University of Oklahoma, 1963.

SELECTED CURRENT AND RECENT AWARDS, HONORS, OFFICES

- Honorary Doctorates: University of Oklahoma, Mt. St. Mary's College, Los Angeles, California, State University of New York, Rome/Utica
- Oklahoma Women's Hall of Fame
- University of Oklahoma College of Engineering Distinguished Graduate Society
- National Space Society Wernher von Braun Award
- Western Engineer's Society Washington Award for Engineering Achievement
- American Society of Mechanical Engineers, Holley Medal for Lifetime Achievement
- *Glamour* Magazine "Women Who Do and Dare" Award
- One of *MS* Magazine's "Women of the Year"
- Women in Technology International Hall of Fame
- NASA Outstanding Leadership Medal for management and systems engineering
- Society of Women Engineers Judith Resnick Award,
- President of the Science Council for the NASA Institute of Advanced Concepts
- Member of the Board of Omniplex Science Museum in Oklahoma City, Oklahoma
- Member, American Society for Engineering Education
- Trustee of Scripps College for Women, Claremont, California

SELECTED RECENT PUBLICATIONS

- Striz, A. and Shirley, D., "Intelligent Aerospace Systems: An Exercise in Curriculum Development", ASEE Midwest Section Meeting, University of Missouri-Rolla, September 10-12, 2003
- D.P. Miller, D. Hougen & D. Shirley, The Sooner Lunar Schooner: Lunar Engineering Education ,Journal of Advances in Space Research , vol. 31/11, pp. 2449-2454, 2003.
- Shirley, D., Baker, R., Deaton, L. and Reynolds, E., "Tinker Air Force Base Phase I Process Improvement Methodology Report", 31 May 2003
- ASEE 2002-406, "Managing Creativity: A Creative Engineering Education Approach", D. L. Shirley, ASEE National Conference, June 2002
- Shirley, D.L. "The Myths of Mars: Why We're Not There Yet, and How to Get There", Workshop on Concepts and Approaches for Mars Exploration, Lunar and Planetary Institute, Houston, TX, 18-20 July 2000
- Shirley, D. L, Written Congressional testimony on "The Root Causes of the Mars Surveyor 98 Mission Failures", requested by the staff for the House Subcommittee on Science and Technology and used in hearings on 30 April 2000.
- Shirley, D. L. "Women in Engineering: Focus on Success", *Bridge*, National Academy of Engineering, summer 1999.
- Shirley, Donna L, Managing Martians - Autobiography published by Broadway Books, with Danelle Morton, 1998, 1999.
- Shirley, Donna L., "Touching Mars", Presented at the IAA Low Cost Systems Conference, Pasadena, CA, August 1998
- Shirley, Donna L. and Matijevic, Jacob, "Mars Rovers: Past, Present and Future", Princeton University Space Studies Institute's 20th Anniversary Conference, Princeton, NJ, 10 May 1997
- Shirley, D. L. and Haynes, N., "The Mars Exploration Program", Space Technology and Applications International Forum (STAIF-97), Albuquerque, NM, 26-30 January 1997.

SELECTED MEDIA APPEARANCES

- Recent (1996-2004) Television Appearances include: Masters of Technology Show #105, Donna Shirley SPACE TECHNOLOGY (http://www.sciam.com/mastertech/), (2002), ABC's *World News Tonight*, ABC's *Good Morning America*, NBC's *Today*, many CNN news programs, the Discovery Channel's *Life on Mars?*, PBS's *Jim Lehrer News Hour*, The Family Channel's *To the Moon and Mars*, *LA Life and Times* on KCET public television, *Charley Rose*, *Tom Snyder*, CSPAN, documentaries by PBS, the BBC, and Australian television, and many other television news programs
- Numerous national and international radio appearances including local and national commercial and educational networks and PBS.

- Print and Electronic Media: Widely quoted and featured in major print media.
- Have given literally hundreds of speeches, nationally and internationally, on management of creative systems, space exploration, education, and diversity.

3911 Bagley Avenue North
Seattle, WA 98103
6 March 2004

Rep. Sherwood Boehlert
Chairman, The House Committee on Science
The Congress of the United States
Washington, D.C.

Dear Rep. Boehlert:

I am pleased to testify before the Committee on Science hearing entitled *Perspectives on the President's Vision for Space Exploration* on Wednesday, March 10, 2004, at 10:00 a.m. in room 2318 of the Rayburn House Office Building.

I certify that I have no current source of federal funding which directly supports this subject matter.

Sincerely,

Donna L. Shirley